1058-13.

AIA FILE No. B-19

MANUAL OF TIMBER CONNECTOR CONSTRUCTION

(1935)

AIA FILE No. B-19

TIMBER ENGINEERING COMPANY

WASHINGTON, D. C.

MODERN CONNECTORS FOR TIMBER CONSTRUCTION were introduced in America by the United States Government which, after extensive study of many connectors abroad, wished to obtain for American industries their economical advantages. For this purpose the National Committee on Wood Utilization of the United States Department of Commerce amassed data on many types of wood and metal connectors in current use in Europe.

With the advantage of joints much stronger than those obtained by bolting only, European engineers had already constructed spectacular timber structures with both imported American structural woods and the weaker native European woods.

Subsequently and in order that prospective users in America might have readily obtainable up-to-date technical information as to the engineering advantages of the most promising connectors and facts regarding their use with American structural species, several connector types were put through rigorous tests by the United States Forest Products Laboratory, Madison, Wisconsin, and the National Committee on Wood Utilization. The results of these basic tests are contained in a 147-page research report prepared jointly by the Laboratory and the Committee, and published by the Government Printing Office.

The design data and technical information presented in the following pages are based on these tests and on study of foreign and American practice.

Printed in U.S.A.
1935

MANUAL OF TIMBER CONNECTOR CONSTRUCTION

Design and Use Data

Timber joint connectors are inexpensive and easily installed devices for improving the efficiency of timber framing. They increase joint strength, reduce the sizes of members required for a given load, and simplify fabrication and erection.

Connections in timber framing customarily are made by lapping the ends of the several members over each other. Contact areas are thus obtained in which loads are transmitted from one member to another.

In these areas of contact, it is possible to develop with bolts only from 40 to 60% of the allowable working load of the members; for this reason timber framed with bolts only is understressed and uneconomical.

Timber connectors now make it possible in most cases to develop the full allowable loads of the members connected; in fact, it is possible under some circumstances to make the joints stronger than the members themselves.

These improved connections enable a pound of good structural timber to do in general the same work that can be expected from a pound of steel. The greatly increased strength secured at crucial points is of such prime engineering importance as frequently to change both the methods of design and cost aspects of many structural types. Timber can now be used economically for types of structures for which it has not formerly been considered, and timber structures can now be designed for wider spans and heavier loads than before.

As compared with the earlier types of notched or hand-fitted joints, timber connectors greatly reduce labor costs. As compared with joint details in which timbers are bolted to steel gussets, the connectors are lighter and cheaper, not only in the weight of metal used, but also in the amount of timber required for a given load and in the assembly labor required. Design features are also greatly simplified because with connectors the strength of joints can be quickly and accurately computed.

The TIMBER ENGINEERING COMPANY, INC., manufactures under American patents and patent rights, and now sells direct or through licensees in the United States, several types of timber joint connectors. Among these are:

TECO *toothed ring* (See Fig. 1)
TECO *split ring* (See Fig. 2)
TECO *shear-plate* (See Fig. 3)

Years of practical building in Europe and thorough laboratory tests conducted in this country by the United States Government have indicated that these three types combine the advantages of economy, efficiency, and general usefulness.

The first two types transmit loads between adjacent wood members. Their fields of use are not always identical, and their methods of installation differ.

The shear-plate transmits loads between wood and steel.

The selection of the connector to be used is largely a matter of engineering analysis of individual projects.

The design data and technical information contained in this pamphlet are directly applicable to structural grades of such American woods as

Tidewater Red Cypress
Douglas Fir
Western Larch
Longleaf and Shortleaf Southern Yellow Pine
Redwood
Tamarack

Similar data and technical information for other species may be obtained upon request to the Timber Engineering Company.

The working loads hereinafter recommended for connectors are based on tests by the Forest Products Laboratory on Douglas Fir and Southern Yellow Pine. Working loads herein recommended for species and variations of properties within a single species, which have not been tested, have been derived by a comparison of the mechanical properties of species; which method has been suggested by the Forest Products Laboratory.

SERVICE FROM THE TIMBER ENGINEERING COMPANY

The Timber Engineering Company maintains a competent staff of engineers and wood technologists to advise with architects and engineers in the design and checking of construction plans calling for TECO connectors.

Through this staff fundamental engineering information needed by designers of connector-built structures is always available. This information includes results of the extensive laboratory tests in the United States and data obtained from the great volume of European and American construction.

The Timber Engineering Company has developed, for assistance of architects and engineers, an extensive series of sample designs showing the use of connectors in buildings and other structures. Among these are trusses for both pitched and arched roofs, radio towers, lookout towers, bridges and trestles, and oil derricks.

Recommended methods of using connectors are exemplified in these designs and information shown on quantities of lumber, bolts and connectors will assist designers in making a quick estimate of the probable cost of work in prospect, if executed in timber-connector construction.

Prints of sample plans will be forwarded on request with a nominal charge to cover postage and blue-printing.

The Timber Engineering Company will also welcome the opportunity to cooperate with prospective users in adapting connectors to new or special purposes.

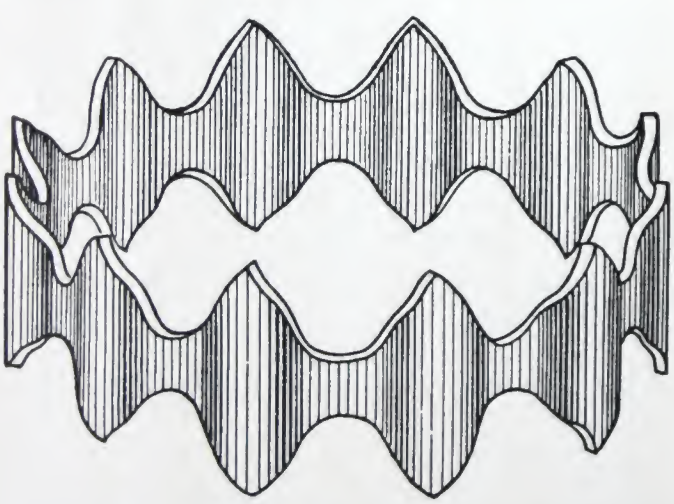


FIGURE 1—A toothed-ring TECO connector is a ring of sixteen gauge hot-rolled steel, ribbed to guard against lateral bending, with sharpened teeth on each edge. These rings, imbedded half their depth in the contacting surfaces of adjacent timbers, transmit loads from member to member. Made in four sizes.

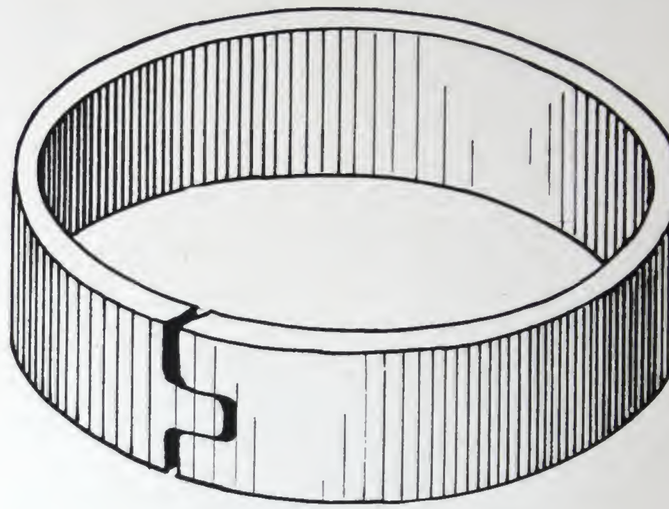


FIGURE 2—A split-ring TECO connector is a smooth ring of steel with a tongue and grooved break or "split" which increases its load capacity. Split rings transmit loads when placed in pre-cut grooves in the faces of adjoining timbers. Made in four sizes.

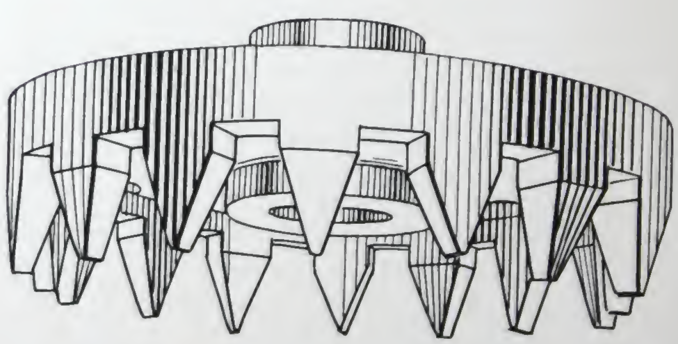


FIGURE 3—A shear-plate TECO connector is a circular, malleable cast iron plate with teeth arranged about an annular rim on one face, to be imbedded in a pre-cut groove in the timber, and a boss on the opposite face to fit a hole in a steel strap or gusset plate. They transmit loads between wood and steel. Made in $3\frac{1}{8}$" diameter only.

Toothed Ring Connectors

Toothed ring connectors are sharp-toothed corrugated rings of sixteen-gauge sheet steel. (See Fig. 1.) When they are used in a joint, a bolt hole is bored through the assembly of lapped timbers, the members are lifted apart and toothed rings are placed between the adjacent faces of members to be connected. The members are then drawn tightly together by the bolt or other suitable means until the rings are completely imbedded in the wood, one-half the depth of each ring entering each adjacent member. (See illustration below).

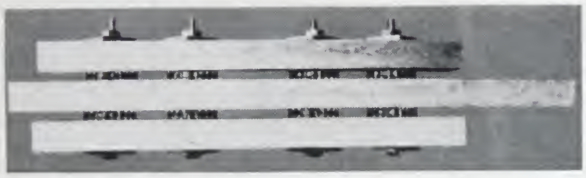


Illustration of the position of toothed-ring connectors in a simple lapped joint. In completing the joint, the connectors are imbedded to one-half their depth in each timber face by drawing up the bolts with a long-handled ratchet wrench.

DESIGN OF TOOTHED RING JOINTS

Installation and specification data for toothed rings and a chart of recommended working loads for the various sizes at different angles to grain are given below.

Safe load values are for the joint assembly, which consists of bolt, toothed ring, two washers and a nut. Loads shown are for two-member joint with one-toothed ring placed between the two timbers (single shear). For the more usual case of a three-member joint in which two toothed rings concentric with the bolt axis are used the values given should be multiplied by two (double shear). The addition of toothed rings increases the joint strength in direct proportion to the number of toothed rings used.

Recommended loads for toothed rings are based on a factor of safety of four on ultimate load because the characteristics of the test curves are such that no proportional limit can ordinarily be determined.

No increase of the loads shown herein is recommended for wind or earthquake load design.

Species:

The design data and technical information apply to:

- Tidewater Red Cypress
- Douglas Fir
- Western Larch
- Longleaf and Shortleaf Southern Yellow Pine
- Redwood
- Tamarack

Similar data for other species of timber will be furnished by the Timber Engineering Company upon request from prospective users.

Seasoning:

Working loads shown are for toothed rings in seasoned timber, i. e., timber which has a moisture content at the time of installation equal to that to which it will eventually come in use. For nearly all parts of the country this will average about 15% for the surfaces of the timber, representing 15% to 20% averaged over the entire cross section of the timber. Loads for toothed rings in green timber should not exceed 60% of those shown, and for intermediate moisture contents the loads should be interpolated according to the degree of seasoning of the timber surfaces.

Bolt Hole Diameters:

"Tight bolt" (see chart) means that bolt hole is made the same size as bolt. "Loose bolt" means that bolt hole is made approximately $\frac{1}{16}''$ larger than diameter of bolt. The standard sizes of carpenter's or machine bits are used.

Ring Metals:

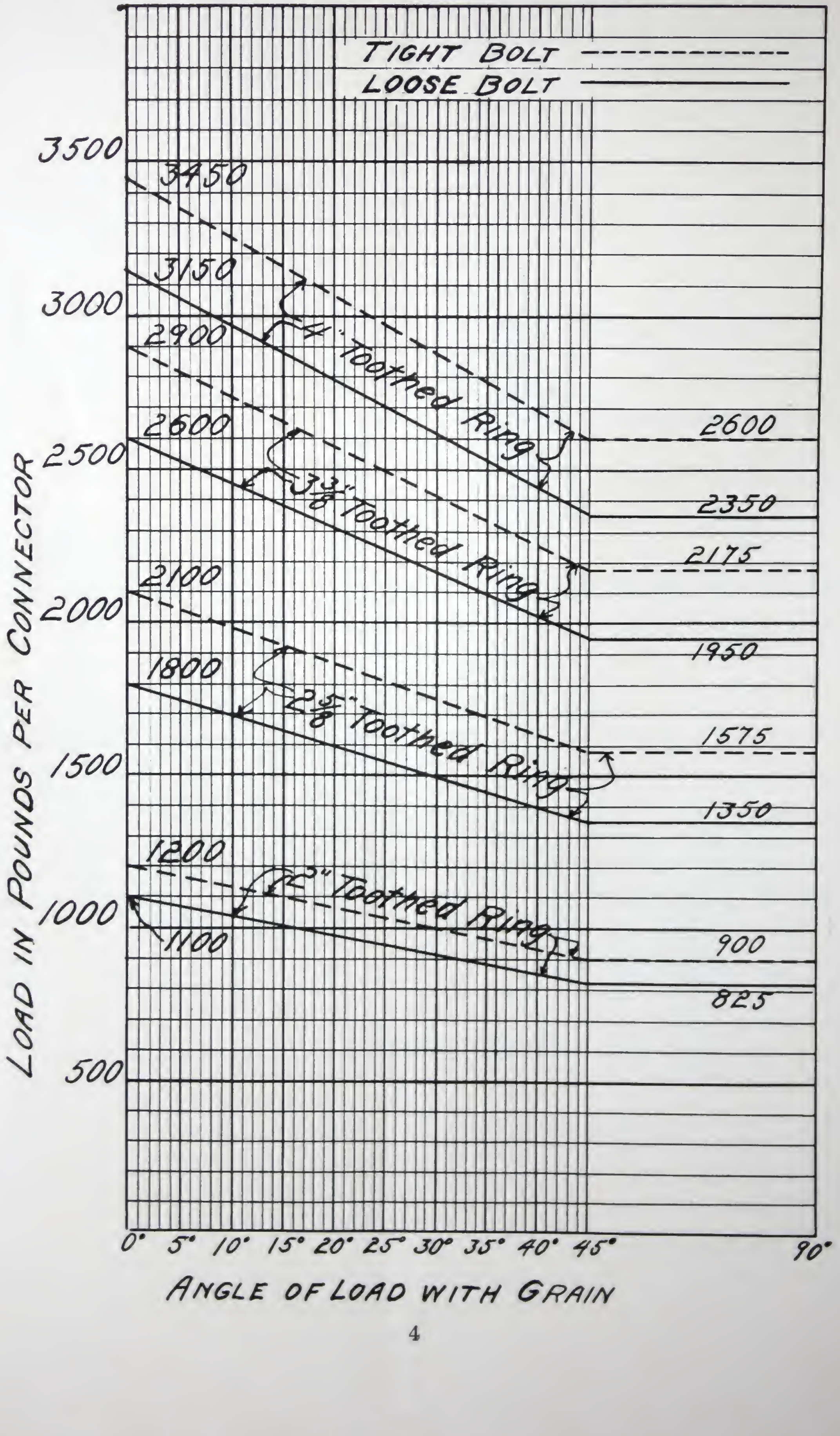
Toothed rings, as ordinarily supplied, are of uncoated steel. They should be galvanized or of non-corrodible metal when used subject to moist conditions except that in structures of creosoted timber the creosote oil will usually afford sufficient protection against corrosion. The use of different metals in bolts and connectors in the same structure may cause electrolysis in moist locations, and should be avoided.

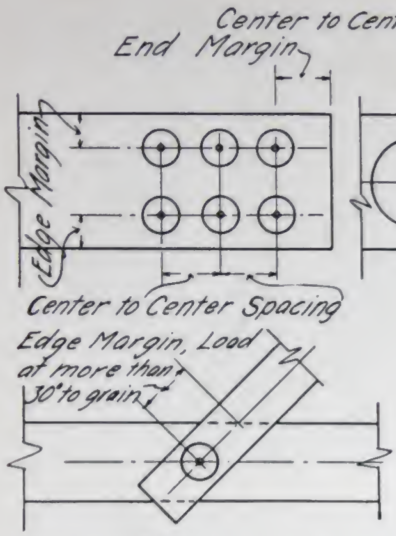
Toothed Ring Spacing and Margins:

The standard end margin (see table on page 5) is equal to the diameter of the ring, and the standard center to center spacing parallel to load is equal to 1.5 times the diameter of the ring. The 2, $2\frac{5}{8}$, $3\frac{3}{8}$, and 4-inch rings may be used in minimum nominal lumber widths of 3, 4, 5, and 6 inches, respectively. The standard edge margin is determined by placing the center of each ring or the bolt hole in the middle of the corresponding minimum face width.

These margins and spacings are measured from the centers of bolt holes as indicated in the sketch on Page 5.

SAFE WORKING LOADS
FOR ONE TOOTHED RING WITH BOLT IN SINGLE SHEAR IN STRUCTURAL GRADES OF ANY STRUCTURAL SPECIES





Spacing between toothed rings in a direction perpendicular to the load may be as close as successful imbedment or washer clearance will permit.

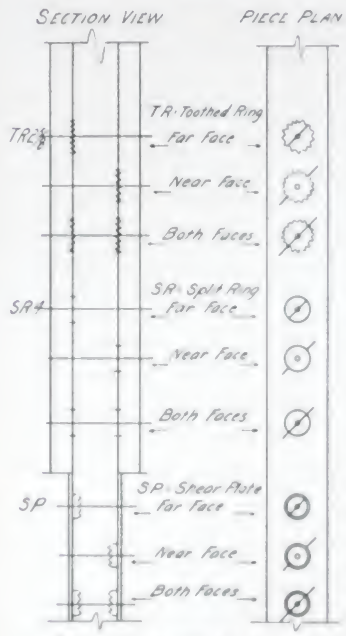
Toothed rings need not be exactly concentric to the axis of the bolt if it is desirable to locate them otherwise, but bolts should be sufficient in number and distribution to secure complete imbedment and reduce influence of eccentricity. Greater end margins than are necessary for full working load should be used where end-checking in one and one-quarter to two-inch dry material is likely to occur during assembly.

Large and small toothed rings may be placed concentrically to the same bolt between the same timber surfaces, in which case the load value is equal to the value recommended for the large ring with its bolt plus 25% of the allowable working load for the smaller ring plus its bolt. (See chart opposite on page 4).

FABRICATION AND ERECTION

Timbers in structures where the toothed ring is to be used require no pre-fabrication except cutting to length and shape.

Procedure in assembling a joint with toothed ring connectors is similar to that when bolts alone are used except that greater pressure must be exerted in turning up nuts and larger washers are necessary to prevent crushing the wood about the bolts. A long-handled wrench is necessary, preferably of the bridge type with ratchet head,* and bolt threads and washer surfaces should be oiled.



Sample legend is shown at the left for indicating the sizes and positions of connectors on structural drawings and shop details.

Legend for toothed rings is unnecessary on shop drawings for toothed ring construction. Size of bolt holes only need be indicated.

Except for structures in which two or more types of connectors are used, it is sufficient to indicate the position of connectors by a plain circle on plans and shop details, the type used being covered by a note.

The usual method of installing toothed rings is to nail or clamp the various members of the structure together temporarily; drill the bolt holes as required by plans;

TOOTHED RING INSTALLATION DATA

Diameter of Ring	Lumber Dimensions			Standard Ring Spacings and Margins		
	Minimum Width	Minimum Thickness		End Margin Tension and Compression	Spacing C-C of Rings Parallel to Load	Edge Margin Tension and Compression
		Rings in One Face Only	Rings Opposite in Both Faces			
Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
2	2 5/8	1 1/16	1 5/8	2	3	1 1/4
2 5/8	3 5/8	1 1/16	1 5/8	2 5/8	4	1 3/4
3 3/8	4 5/8	1 1/16	1 5/8	3 3/8	5	2 1/4
4	5 1/2	1 1/16	1 5/8	4	6	2 3/4

* All items marked thus are available on a nominal rental or purchase basis from the Timber Engineering Company or its Licensees.

pry the members of each joint apart; insert the toothed ring or rings, holding them in place with small nails; insert bolt with washers of suitable size under both head and nut; and draw the toothed ring into the wood members by tightening up on the bolt.

This method of installation requires a bolt equal in length to the total thickness of members plus one inch for each toothed ring concentric to the bolt. One inch also must be added for a nut and plate washers or two inches for a nut and ogee washers. The additional bolt length permits starting the nut before the toothed rings are imbedded.

When more than two rings are used concentric to the axis of a bolt the bolt should be threaded for a sufficient length to provide for their complete imbedment.

The above method of installation may be impracticable for toothed rings where the timbers are very dry and/or of a dense and relatively hard species such as Douglas fir, Southern pine and most of the hardwoods. In such cases, and always with galvanized bolts, the prior use of a high strength steel rod,* threaded on both ends, with oversize plate washers * and double-depth nuts * is recommended. The rings are first imbedded with the high strength rod, after which the rod is removed from the bolt hole and the regular bolt is installed. This will avoid stripping the threads of the ordinary bolt; make it unnecessary to use extra long bolts in the final assembly; prevent checking or splitting of the timbers; and do away with any local crushing of wood under the washers. It requires a considerable pressure to imbed the larger toothed rings in dry dense timber and the use of the high strength rods, oversize plate washers and a ratchet wrench will not only give a more satisfactory joint but will also prove economical of labor. A little oil on the high strength rod and the use of two cut washers between the nuts and the

The cut away piece in the assembly at the right shows a toothed ring with half its depth imbedded in the center timber and half projecting into the side member.

Seating TECO toothed-ring connectors by use of a long-handled ratchet wrench

82-foot Fink trusses for a riding hall. Connections made with TECO split rings.

* All items marked thus are available on a nominal rental or purchase basis from the Timber Engineering Company or its Licensees.

plate washers will make installation easier. The thread of the double-depth nut should be cut to a diameter slightly larger than that of the rod, in order to avoid "freezing" of the nut when the rod expands as joint is being drawn together.

After the members of a truss or other structure are pre-fabricated (i. e., cut to length and shape, and bored) and delivered to the job ready for assembly, the toothed rings may be driven half-way into one of the timbers by means of a TECO recessed follower.* Imbedding the rings in the timber by any method which bends or blunts the teeth, or which may cause the ring to go more than one-half its depth into the timber, should be avoided. Where toothed rings are half imbedded with a follower, bolt lengths should be adjusted accordingly. Pre-fabricated members, with the ring inserted in one member before the joint is assembled, can sometimes be used with a considerable saving in labor costs.

Various forms of U clamps, C clamps, screw-jacks and hydraulic jacking devices also have been used successfully to imbed toothed rings. The fact that one timber in a joint may be harder than the adjacent timber, resulting in deeper imbedment in the soft timber than in the hard one, is compensated for by the fact that the resistance of the hard timber to bearing against the ring surface is greater than the resistance of the soft timber. The difference in penetration has proved negligible.

In assembling joints where two or more bolts with connectors are required all bolts should be pulled up evenly to avoid "canting" of the rings.

It will also be found that the assembly of joints is more economical if the bolt holes are made 1/16" larger than the bolts. While this may decrease the safe working load of the joint by as much as 10% it materially increases the ease of installation.

Toothed rings may be used at the safe loads here stated with bolts larger than those recommended in the table of specification data. It is frequently desirable and economical to use only one size of bolts and rings on a job even though a smaller size might suffice for some of the joints. When two sizes of toothed rings are installed with the same bolt, the larger of the prescribed bolts should be used.

SPECIFICATION FOR TOOTHED RINGS

Toothed rings shall be made from 16-gauge hot-rolled sheet steel. They shall be stamped and bent cold to form a circular, corrugated, sharp-toothed band, and welded into a solid ring. All dimensions shall conform to those specified by the Timber Engineering Company.

The teeth on each ring shall be on a true circle, and shall be parallel to the axis of the ring. Workmanship shall be perfect and in strict accord with the ring manufactured by the Timber Engineering Company.

The toothed rings required to be hot-galvanized shall be galvanized to conform to A.S.T.M., Standard Specifications A 123-33. (See page 19)

Toothed rings shall be of the following sizes and weights and shall be installed with washers and permanent bolts not less in size than specified below. (Ascertain from table below.)

TOOTHED RING SPECIFICATION DATA

Order Number	Sizes and Weights			Bolt and Washer Sizes		
					Washers	
	Diameter of Ring *Inches*	Overall Depth of Ring *Inches*	Weight per 100 Rings (Hot Rolled Steel) *Pounds*	Minimum Diameter of Bolt *Inches*	Square Plate *Inches*	O. G. *Inches*
1	2	1 5/16	5.7	1/2	2 x 2 x 3/16	1/2 x 2
2	2 5/8	1 5/16	7.4	5/8	2 1/2 x 2 1/2 x 1/4	5/8 x 2 1/2
3	3 3/8	1 5/16	9.2	3/4	3 x 3 x 3/8	3/4 x 3
4	4	1 5/16	11.1	3/4	3 1/2 x 3 1/2 x 3/8	7/8 x 3 5/8

NOTE: For weight of galvanized rings add approximately 10 per cent.

* All items marked thus are available on a nominal rental or purchase basis from the Timber Engineering Company or its Licensees.

Split Ring Connectors

Split ring connectors are plain steel rings made with a rectangular cross section and a tongued and grooved break in the perimeter.

For assembly of a split ring joint one or more bolt holes are bored in the timbers to be joined at points indicated on the plans. Circular grooves one-half the depth of the ring parallel to its axis are cut in the contacting surfaces of the timbers using a special grooving tool* with a pilot which centers in the bolt hole already bored. The split ring is then placed in the groove in one timber, the other timber is fitted over it, and the joint is drawn tight with the bolt, which remains in the joint.

The break or "split" in this type of connector is made in the form of a tongued and grooved joint and is important. A solid ring, in transmitting loads, may bear against only the wood outside the groove, or only the wood core within. The split ring bears against both and therefore is able to transmit higher loads. In order to secure this double action regardless of the moisture content of the timbers at the time of installation, the diameter of the groove cut in each timber is made slightly greater than the diameter of the ring (see table page 12). When inserting the ring in the grooves it is, therefore, necessary to pry it apart; and the opening of the ring thus obtained at the split assures the double action at all times, either with dry or green timbers. The split in the ring should be placed nearest the edge of the member stressed parallel with the grain.

Left: Position of split rings in a typical splice of a spaced timber column. Exhibit joint is broken down to illustrate the opposing grooves in timber faces into which the rings fit and bear both against core and rim. Right: Typical panel point detail for a connector-built oil derrick.

This type of grooving tool for $2\frac{1}{2}$, 4, and 6-inch TECO split rings is provided with interchangeable shanks for use in power equipment and for cutting grooves by hand. The latter shank has a pilot threaded to draw the tool into the wood at the proper speed for hand operation.

Cutting grooves for split rings with a portable pneumatic drill.

DESIGN OF SPLIT RING JOINTS

Installation and specification data for split ring connectors and charts of recommended working loads for the various sizes at different angles to grain are given on pages 10 to 13.

Working load recommendations for TECO split rings as well as other TECO connectors are limited to structural grades of timber in order to avoid cross grained pieces and undesirable combinations of knots and shakes at connection points. Loads shown on the charts for split rings in dense grades of timber are greater because of the more homogeneous character and the greater shear strength and end bearing capacity of such material. Dense material must show not less than 6 annual rings and, depending upon the species, not more than 20 to 30 rings per inch, and in addition not less than one-third summerwood on either one end or the other of each piece.

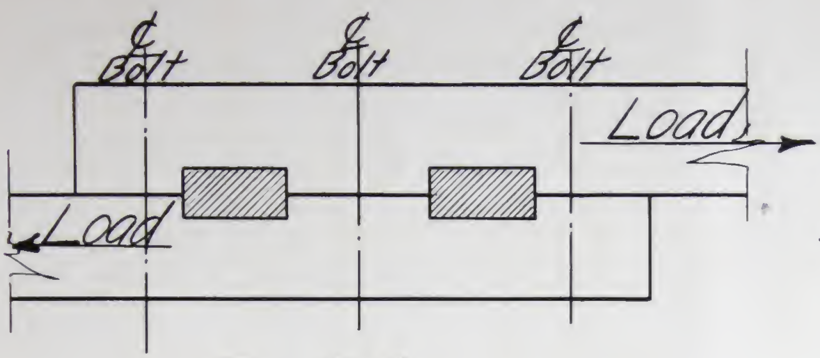


Fig. 5-A

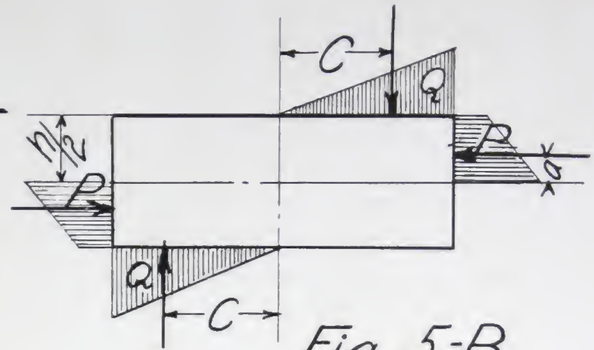


Fig. 5-B

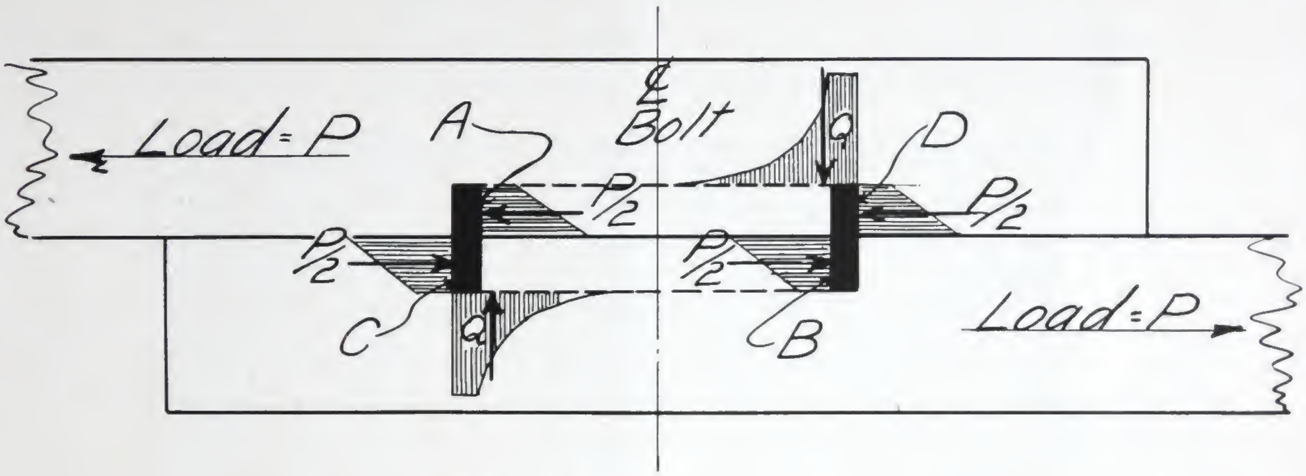


Fig. 5-C
Action of Split Ring Connector

FIGURE 5—When it has been required in the past to transmit load between two timbers in contact, shear blocks have often been employed, inserted half their depth in each of the contacting faces as shown in Figure 5 A. When load is brought to bear on such a block, the resulting pressures are as shown in Figure 5 B. Sufficient distance must be provided between blocks to develop the shear which will balance the pressure P on end grain. The block also must be wide enough so that the resisting moment due to pressure Q perpendicular to grain, balances the overturning moment due to the pressure P. This moment is finally taken as tension by the bolts through the joint. Since allowable unit stress in bearing on end grain is about ten times that in shear, and five times that perpendicular to grain, the width of the block and the spacing of blocks must be considerable. The dap for the block materially reduces the net section of the timber and requires larger sizes to be used. The shear resistance represented by the area of the blocks is lost entirely. When a joint made with split rings is loaded, the local stresses developed around a ring are as shown in Figure 5 C.

Due to the break or "split" in its perimeter the ring is to some extent flexible in the direction of the load. Since the cores are larger than the rings, wood and steel are already in contact at A and B when the load on the members is applied and these surfaces come promptly into bearing. A slight slip in the joint takes place, due to the difference between groove width and thickness of the ring metal. The portion of the ring, A-C, moves in the direction of the load P until steel comes into bearing against the wood on the surface C. The same relative movement of the loaded pieces brings about bearing also on the surface D. Thus twice as much wood surface is brought into bearing against the shear device as in the case of the solid shear block, and the shear area in the wood available to take up this bearing is equal to the whole surface within and between rings minus the relatively small area of the groove itself. The overturning moment on the ring is resisted by the moment due to pressure Q. There is less area to support this pressure perpendicular to grain than in the case of the shear block, but the ring is so proportioned in thickness and width as to avoid failure in this direction, even at ultimate loads.

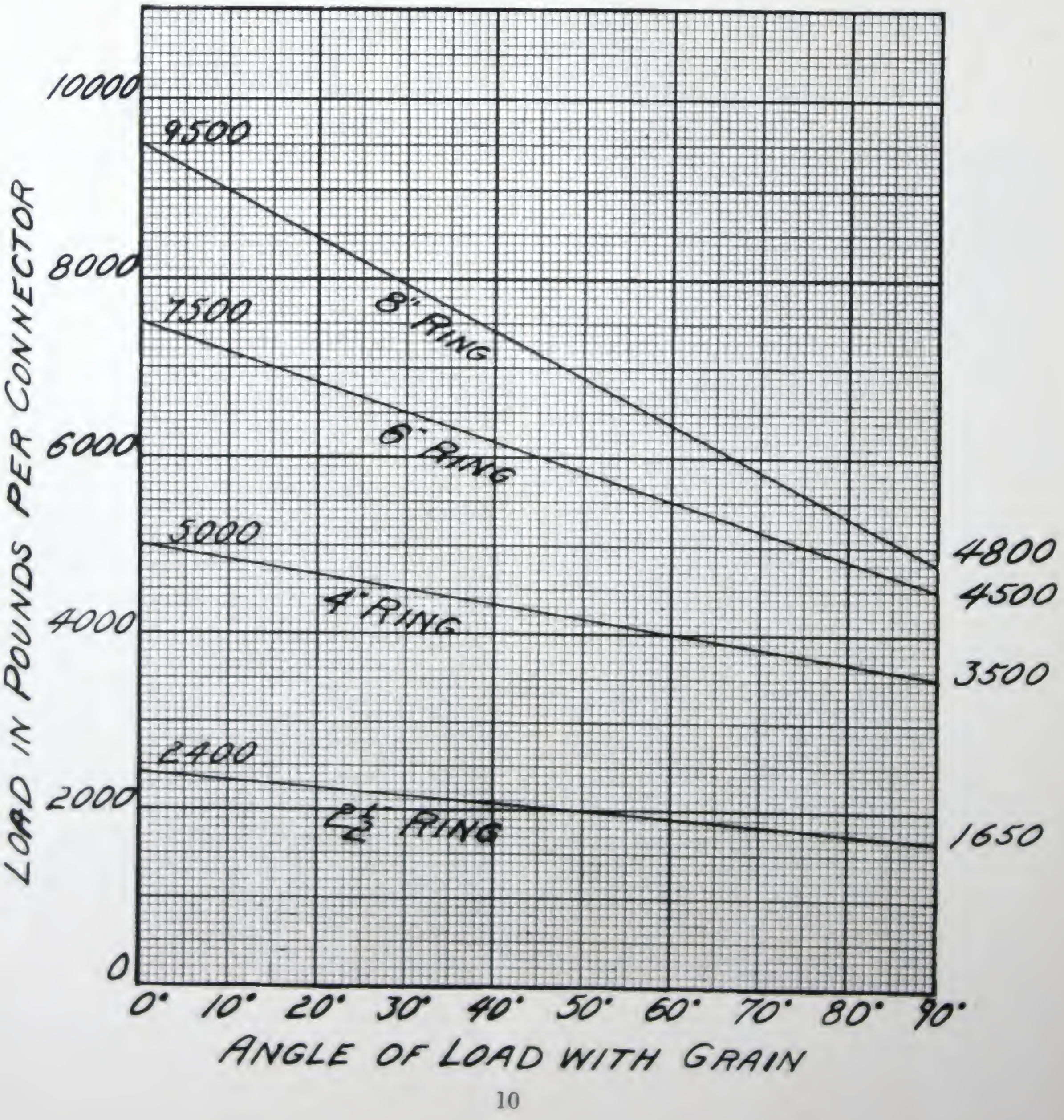
Tests show that in the smaller sizes of split rings first failure occurs through shear of the cores, and in the larger sizes by failure of the wood fiber in bearing on the surfaces of contact with the ring.

Safe load values are for the joint assembly, which consists of bolt, split ring, two washers and a nut. Loads shown are for two-member joint with one split ring placed between the two timbers (single shear). For the more usual case of a three-member joint in which two split rings concentric with the bolt axis are used the values given should be multiplied by two (double shear). The addition of split rings increases the joint strength in direct proportion to the number of split rings used.

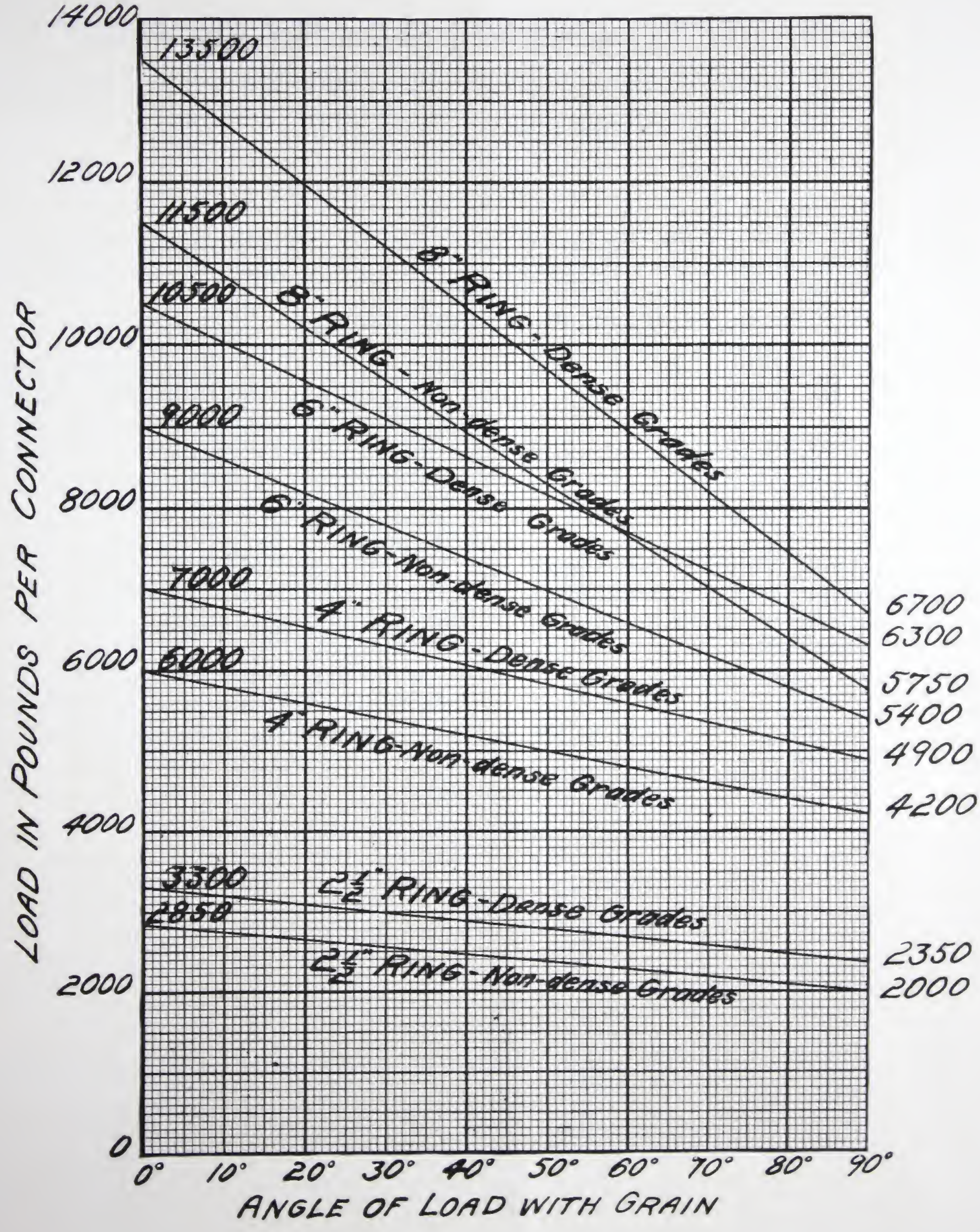
Recommended loads for split rings are based on a factor of safety of 3.5 on ultimate strength or 1.6 on proportional limit, whichever gives the smaller result. Such recommendations are more conservative than those of engineers in the foreign countries where connectors were developed and have been largely used. Designers should consider the character of loading, i.e.: whether steady or intermittent, and the proportion of dead load to total design load in using the recommended safe loads given herein.

No increase of the loads shown herein is recommended for wind or earthquake load design.

SAFE WORKING LOADS FOR ONE TECO SPLIT RING AND BOLT IN SINGLE SHEAR IN STRUCTURAL GRADES OF TIDEWATER RED CYPRESS AND CALIFORNIA REDWOOD



SAFE WORKING LOADS
FOR ONE TECO SPLIT RING AND BOLT IN SINGLE SHEAR IN DENSE AND NON-DENSE STRUCTURAL GRADES OF DOUGLAS FIR, WESTERN LARCH, SOUTHERN YELLOW PINE, AND TAMARACK



Species:

The design data and technical information apply to
- Tidewater Red Cypress
- Douglas Fir
- Western Larch
- Longleaf and Shortleaf Southern Yellow Pine
- Redwood
- Tamarack

Similar data for other species of timber will be furnished by the Timber Engineering Company on request from prospective users.

Seasoning:

No adjustment need be made in the recommended working loads for split rings installed in unseasoned material which will within a reasonable period reach a seasoned condition. Loads for split rings in timber which will continue in a green or saturated condition should be reduced $33\frac{1}{3}\%$.

Bolt Hole Diameters:

Bolt holes should be $\frac{1}{16}''$ oversize, using the standard sizes of carpenter's or machine bits.

Ring Metals:

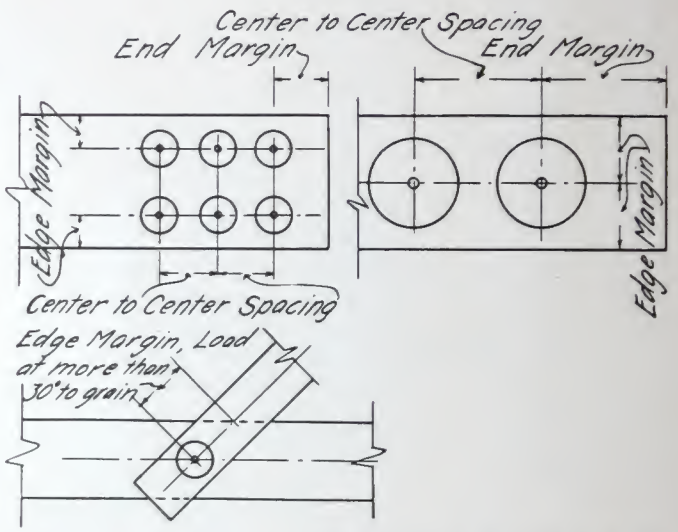
Split rings, as ordinarily supplied, are of uncoated steel. They should be galvanized or of non-corrodible metal when used subject to moist conditions, except that in structures of creosoted timber the creosote oil will usually afford protection against corrosion.

The use of different metals in bolts and connectors in the same structure may cause electrolysis in moist locations, and should be avoided.

Split Ring Spacing and Margins:

The standard minimum end margin and the standard center to center spacing in the table for split ring installation data are equal to 1.5 times the diameter of the ring. The standard minimum edge margin for each ring is determined by placing the center of the ring or the bolt hole in the middle of the corresponding minimum face width.

These margins and spacing of rows of connectors are measured from the centers of bolt holes as indicated in the sketch below.



The 2½, 4, 6, and 8-inch rings may be used with the loads shown on the charts, in nominal lumber widths of 4, 6, 8, and 10 inches, respectively, provided the angle of load to grain does not exceed 30°.

SPLIT RING INSTALLATION DATA

Inside Diameter of Ring When Closed	Lumber Dimensions			Groove Dimensions		
	Minimum Width	Minimum Thickness: Rings in One Face Only	Minimum Thickness: Rings Opposite in Both Faces	Inside Diameter of Groove	Width of Groove	Depth of Groove
Inches	Inches	Inches	Inches	Inches	Inches	Inches
2½	3⅝	1 5/16	2⅝	2.56	.18	.37
4	5½	1⅝	2⅝	4.08	.21	.50
6	7½	2⅛	3⅝	6.12	.27	.62
8	9½	2⅝	4½	8.14	.34	.75

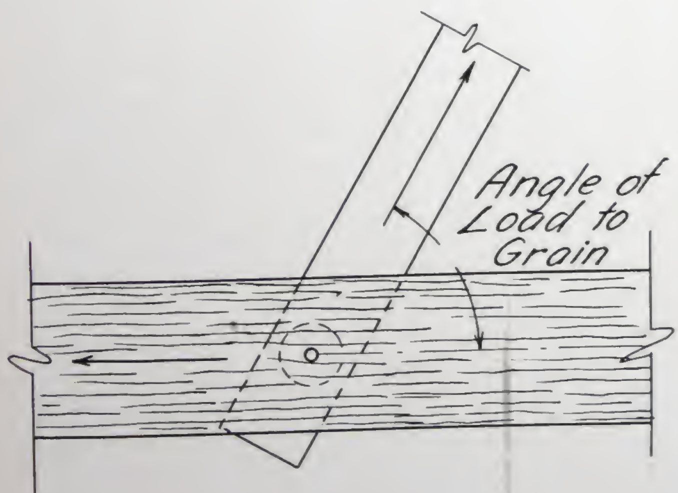
Standard Minimum Spacings and Margins Required
When Loads Are Applied Parallel to Grain or at Angles ***NOT EXCEEDING*** *30° to Grain*

Inside Diameter of Ring When Closed *Inches*	End Margin (Tension and Compression) *Inches*	Spacing C to C of Rings		Edge Margin (Tension and Compression) *Inches*
		Parallel with Direction of Load *Inches*	Perpendicular to Direction of Load *Inches*	
2½	3¾	3¾	3½	1¾
4	6	6	5	2¾
6	9	9	7½	3¾
8	12	12	9½	4¾

The spacing of rows of rings should be sufficient to afford at least ½″ of wood between the outer edges of adjacent grooves.

Edge Margins Required When Loads Are Applied at Angle to Grain ***EXCEEDING*** *30 Degrees*

When the angle of load to grain exceeds 30 degrees, in any member of a timber joint, the loads given on the charts must be decreased unless the edge margin given in the table above is increased. For the full load shown on the charts the edge margin, *measured in the direction of the load*, should be as shown in the following table. When conditions require narrower margins the working loads shown on the charts should be reduced in straight line ratio between the limits shown below. An edge margin less than shown in the right-hand column is not recommended for rings loaded at more than 30 degrees to the grain.



Edge Margins for Loads at Angle to Grain ***EXCEEDING*** *30 Degrees*

Diameter of Ring *Inches*	Edge Margin Required for Full Load Shown on Chart *Inches*	Minimum Permissible Edge Margin (Reduce Safe Load 15%) *Inches*
2½	2¾	1¾
4	3¾	2¾
6	4¾	3¾
8	5¾	4¾

End Margin Reductions Reduce Loads

When conditions require that the standard end margin be reduced from that shown in the table above, the loads shown on the charts should be reduced proportionately between the limits shown below, for rings in *tension* members. End margins less than those shown in the right-hand column, leaving less than 1″ of wood outside of the groove, are not recommended for either tension or compression members.

Reduced End Margins

Diameter of Ring *Inches*	End Margin Required for Full Load Shown on Chart *Inches*	Minimum Permissible End Margin (Reduce Safe Load 33%) *Inches*
2½	3¾	2½
4	6	3¼
6	9	4¼
8	12	5½

FABRICATION AND ERECTION

Timbers to be used in structures where split rings are incorporated in the joints must be pre-fabricated, at least to the extent of cutting the ring grooves in each timber, before the structure is bolted together. For this reason the use of the split rings is more economical when the entire fabrication (boring bolt holes, cutting ring grooves, and sawing timbers to exact length and shape) can be done at a planing mill or other concentration point where stationery drill presses, saws and similar equipment are available.

The use of hand-operated grooving tools on the job is feasible, however, where shop equipment and power are not available, or the size of the job does not justify or permit shop fabrication; many of the larger structures thus far erected in the United States have been successfully completed with the use of portable power drills and hand equipment operated at the sites. Efficient equipment, including the customary carpenters' tools, hoisting apparatus, such as high lines or derricks, as well as the special grooving tool * required for the split rings, is essential if economical and satisfactory results are to be obtained in this type of construction.

On large jobs, such as bridges, towers, roof trusses, etc., it is feasible to lay out one unit (such as a trestle bent or one face of a tower) on the ground, tack the members together temporarily, bore the bolt holes, lift the members apart, marking each one for future identification, cut the ring grooves, and then either bolt the unit together with split rings in place or transport the individual marked pieces to their proper position in the structure and bolt them together "in place."

On the other hand, fabrication of individual pieces may be done at a mill at any distance from the site of the structure. Shop drawings are prepared and detailed in much the same manner as is customary for steel framed structures. Many imaginary difficulties, and a few real ones, have been encountered and successfully overcome in this method of construction. Aside from the customary penalties of sloppy and inaccurate work, such difficulties will be avoided if the following practice is observed:

(1) *All bolt holes in a piece should be laid out accurately from the same end of the piece and, usually, from the centerline of the piece and not from an edge.*

An accuracy of $\frac{1}{32}''$ in laying out work is necessary and obtainable. While it is often desirable, and sometimes feasible, to lay off bolt holes from one edge of a timber, such practice is not recommended when slight

A truck load of timbers pre-fabricated at the plant and hauled to the job site and ready for assembly into the completed structure.

variations in timber sizes could result in a misfit between successive timber frames several feet apart. In punch marking timbers for bolt hole centers a fine nail, or other instrument which will not follow the grain of the wood, should be used.

(2) *Bore bolt holes perpendicular to the face of the timber.*

This is readily accomplished in a stationary drill press and, with proper care, can be approximated with portable drills or hand equipment.

(3) *Use proper tools.*

A barefoot augur is most satisfactory for boring holes by hand through any considerable thicknesses of timbers. A machine bit has been found thoroughly satisfactory for use in a drill press boring of holes up to six inches depth, but difficulties are experienced in clearing this type of bit when used in deeper holes. A ring-groove cutter * designed for the purpose, is essential to a successful job. As previously mentioned, the ring grooves in timbers are made slightly wider than the thickness of metal in the ring, and the inside diameter of the groove or the outside diameter of the wood core is also slightly larger than the diameter of the closed ring. It is necessary to check the tool after drilling 200 or more grooves, and to keep it sharpened so that all groove dimensions will remain approximately constant. Portable electric or air drills for operating the grooving tool should take a $\frac{1}{2}''$ diameter shaft. The speed of the tool depends upon the type of tool and condition of the timber. A few trial cuts will determine the best speed under the conditions at hand. A $\frac{3}{4}$ horse power motor is desirable.

For ring grooves cut by hand, a regular groove-cutting tool is used with a shaft to fit an ordinary carpenter's brace. A threaded pilot will help draw the tool into the bolt hole.

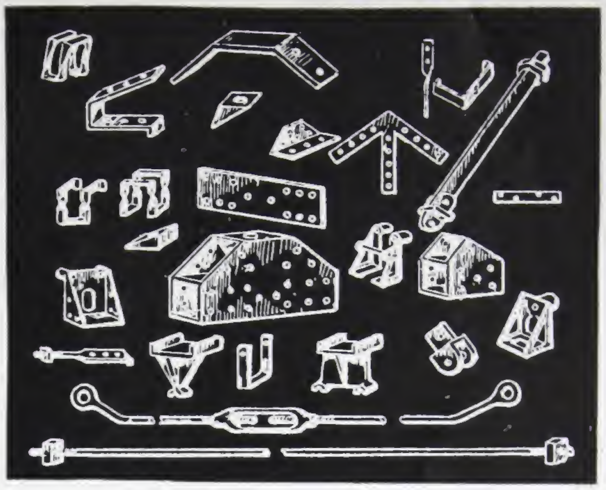
* All items marked thus are available on a nominal rental or purchase basis from the Timber Engineering Company or its Licensees.

A ring expander* is sometimes used for placing the split ring in the groove in the timber. However, with a little practice, it has been found satisfactory to insert the ring in the grooves with a hammer, starting the ring at that portion of its circumference which is ¼ the way around from the split. When, for any reason, it is desired to remove a ring from a timber the ring should be gripped with the claw of a hammer on one side of the split, the hammer pulled up and outward away from the split.

TYPICAL SPECIFICATION FOR SPLIT RINGS

Split rings shall be made of strips of mild steel. Each ring shall be cut through at one point in its circumference in such a way as to form a tongue and slot. Dimensions of split rings shall be (ascertain from table below).

Each ring shall form a true circle including the tongue and slot, and shall spring shut. The band shall be flat with cylindrical surfaces parallel to the axis of the ring. The metal shall be smooth and free of rust.



Types of heavy and costly joint hardware which the use of TECO connectors eliminates. With but a fraction of the weight of these metal parts, TECO connectors often double their structural efficiency.

Installation:

A circular groove, concentric with the bolt hole, shall be cut in adjacent timber faces for each split ring, with power driven equipment and a special grooving tool.* Dimensions of grooves shall be (ascertain from table below) and have a tolerance, plus or minus, of not more than .01 inch:

Allowance should be made for washer thickness in the lengths of bolts specified. When a bolt is to pass through several members an inch of additional length is desirable to facilitate assembly.

Grooves and bolt holes shall be clean cut, without splintered edges, and all chips removed before insertion of the ring. Rings shall be installed with a tool which spreads the ring to the width of the core, or by other suitable means which do not injure the ring or the wood core. Rings shall be placed with the break nearest to the edge of the timber stressed parallel with the grain. Timbers with ring grooves from which the cores may have loosened shall be at once removed from the site and a new piece substituted.

Galvanizing:

Split rings required to be galvanized shall be galvanized to conform to ASTM Standard Specifications A 123-33. (See page 19)

SPLIT-RING SPECIFICATION DATA

Sizes and Weights					Bolt and Washer Sizes		
Order Number	Inside Diameter of Ring When Closed	Depth of Ring	Thickness of Metal	Weight per 100 Rings (Hot Rolled Steel)	Minimum Diameter of Bolt	Washers	
						Plate	O. G.
	Inches	*Inches*	*Inches*	*Pounds*	*Inches*	*Inches*	*Inches*
1	2½	¾	.156	27.3	½	2 x 2 x ⅛	½ x 2½
2	4	1	.187	66.4	¾	3 x 3 x 3/16	¾ x 3¼
3	6	1¼	.250	172.7	¾	3 x 3 x ¼	¾ x 3¼
4	8	1½	.312	351.2	1	3½ x 3½ x ⅜	1 x 4

NOTE: For weight of galvanized rings add approximately 4 percent.

* All items marked thus are available on a nominal rental or purchase basis from the Timber Engineering Company or its Licensees.

Teco Shear Plates

TECO shear-plate connectors are designed to transmit loads from wood to steel, or vice versa.

A shear-plate (see Fig. 3) is a malleable casting consisting of a circular plate with teeth arranged about the perimeter of one face, and a cylindrical hub on the opposite face concentric to a hole for the bolt which holds the assembly together.

The toothed face is partly fitted and partly imbedded in the timber until the outside face of the shear-plate is flush with the surface of the wood. The projecting hub on the outside face fits into a hole in the steel plate or shape to which connection is to be made.

Shear-plates are convenient for footing connections when a tension load must be transferred to anchor bolts, and in general for all situations where steel-to-wood connections are desired.

DESIGN OF SHEAR-PLATE JOINTS

Installation and specification data for TECO shear-plates and a chart of recommended working loads at different angles to grain are given below.

Safe load values are for the joint assembly, which consists of bolt, shear-plate, steel plate or strap engaging the shear-plate, two washers and a nut. Loads shown are for one shear-plate and bolt, acting in single shear between wood and steel. For the more usual case in which two shear-plates are installed on opposite faces of a timber concentric with the bolt axis the values given should be multiplied by two (double shear).

Recommended loads for shear-plates are based on a safety factor of four on ultimate load because the characteristics of the test curves are such that no proportional limit can ordinarily be determined.

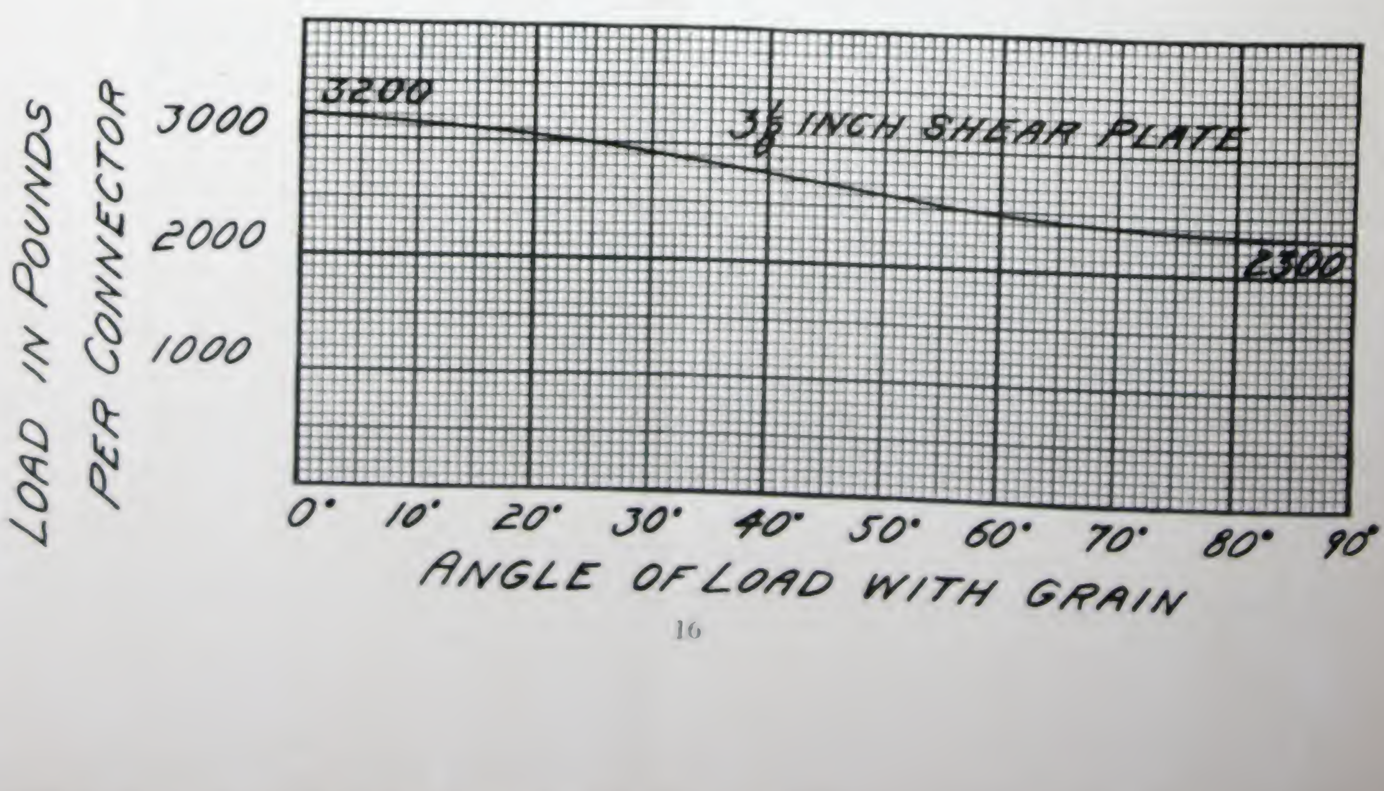
No increase of the loads shown herein is recommended for wind or earthquake load design.

Species:

The design data and technical information apply to:

Tidewater Red Cypress
Douglas Fir
Western Larch
Longleaf and Shortleaf Southern Yellow Pine
Redwood
Tamarack.

SAFE WORKING LOADS
FOR ONE TECO SHEAR PLATE AND BOLT
IN STRUCTURAL GRADES OF ANY STRUCTURAL SPECIES



SHEAR-PLATE INSTALLATION DATA

Lumber Dimensions			Standard Minimum Spacing and Margins for Full Load			Steel Strap Margin and Unsupported Length	
Minimum Width	Minimum Thickness		End Margin	Spacing C-C of Plates	Edge Margin	End Margin	Maximum Allowable Unsupported Length
	Plates in One Face Only	Plates Opposite in Both Faces					
Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
4⅝	1⅝	2⅝	5	5	$2^5/_{16}$	2	12

Similar data for other species of timber will be furnished by the Timber Engineering Company on request from prospective users.

Seasoning:

Recommended working loads for shear-plates need not be reduced for condition of seasoning.

Bolt Hole Diameters:

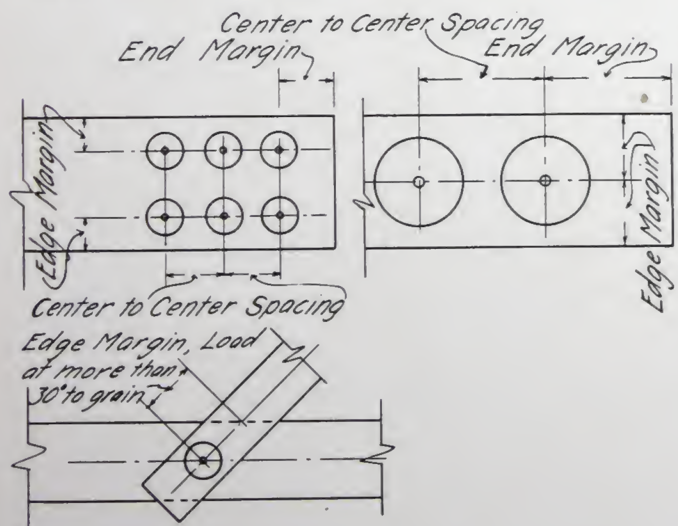
Bolt holes should be $^9/_{16}$ inches in diameter, and in large timbers should be bored half-way from opposite faces, using a standard carpenter's or machine bit.

Plate Metal:

TECO shear-plates as ordinarily supplied are malleable cast iron.

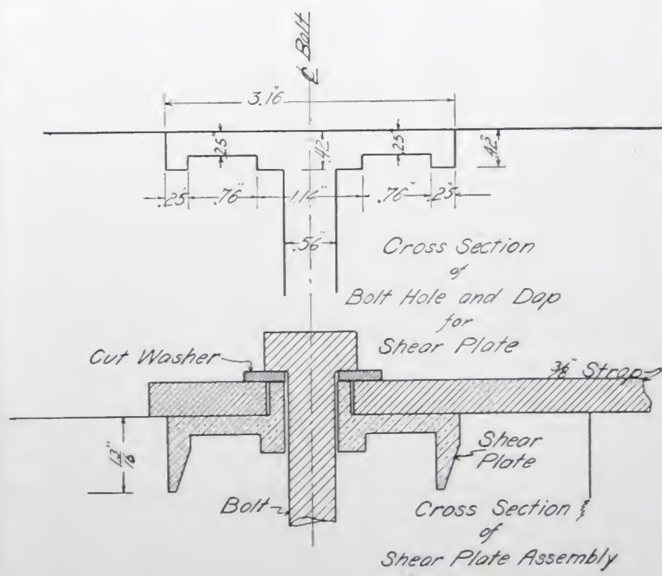
Shear-plate Spacing and Margins:

Edge margin, end margin and center to center spacing are measured from the center of the bolt holes as shown in the sketch below. Grooves for shear-plates must be cut with special tools furnished by Timber Engineering Company.



The safe working loads shown on the chart for one shear-plate acting parallel or at not more than 30 degrees to grain, may be used with the standard end and edge margins given above. When the angle of load to grain exceeds 30°, the edge margin should be not less than 2¾ inches, i.e., a 6-inch nominal width of timber is required for full load. When a lesser edge margin is desirable, working loads shown on the chart should be reduced in straight line ratio from 100% at an edge margin of 2¾ inches to 67% at an edge margin of $2^5/_{16}$ inches. Edge margins less than $2^5/_{16}$ inches measured from the center of plate to edge of timber are not recommended for loads at an angle of more than 30 degrees to grain.

Recommended working loads in tension parallel to grain should be reduced in straight line ratio from 100% at the standard 5-inch end margin to 67% at 3-inch end margin. An end margin of less than 3 inches is not recommended for shear-plates in tension or compression members.



In footing connections and elsewhere it may be desirable to stagger shear-plates to utilize commercial widths of lumber and reduce length of connection plates. Two rows 2 inches apart are suggested, which with the recommended edge margins corresponds to commercial timber face widths of 6½″ and 7½″, depending upon load acting under an angle of less or more than 30 degrees to grain. For each individual shear-plate in such a case, apply the rules given above for margins, spacing, and reductions in load.

Steel Straps or Shapes:

Holes in steel plates or shapes for insertion of shear-plate hubs should be 15/16″ diameter, drilled or reamed holes. The shear-plate is designed for use with steel straps or shapes ⅜″ in thickness, but ¼″ or 5/16″ straps or shapes may be used if washers of suitable size drilled with 15/16″ diameter holes are provided to take up the difference between ⅜″ and the designed thickness of the strap or shape used. A cut washer with hole for a half-inch bolt must be used under the bolt head and nut to distribute bearing to the plate. Care must be taken to provide sufficient net section of the steel to develop the working loads of the shear-plates to which connection is made, and to avoid failure by buckling.

Fabrication and Erection

Daps and grooves for shear-plates are cut in one operation with a dapping tool * specially designed for the purpose. It is provided with a pilot closely fitting the bolt hole and a shaft for motorized or pneumatic equipment. For hand operation, a special shaft is obtainable, the shank of which will fit a carpenter's brace. The pilot may be threaded to assist drawing the tool into the wood.

Where connections are made with shear-plates, it is usually feasible and desirable to use the steel plates, straps or shapes as templates in laying out the timbers for boring and grooving.

Shear-plates may be imbedded by blows with a sledge, using a follower to protect the projecting hub, or they may be drawn into the wood by bolts.

Other rules and precautions for framing of timbers for shear-plate connections are substantially the same as those previously given for toothed and split rings.

TYPICAL SPECIFICATION FOR SHEAR-PLATES

Shear-plates shall be those manufactured by Timber Engineering Company, or their equivalent. They shall consist of a circular plate with teeth arranged about the perimeter of one face, and an integral, cylindrical hub on the opposite or outside face concentric to a hole for a bolt. Shear-plates shall be manufactured of good grade malleable cast iron thoroughly annealed and conforming to the Standard Specifications for Malleable Iron Castings of the American Society for Testing Materials, A-47-33. Plates shall be of smoothly cast metal, free of flaws or fins, of the following dimensions: (Ascertain from table below).

The structural steel used in straps, steel shapes, and gusset plates shall conform to the requirements of American Society for Testing Materials Standard Specifications for Structural Steel for Buildings, Serial designation A-9, as amended to date. Dimensions of straps or shapes shall afford sufficient net section to develop the full allowable load of the shear-plates to which they are attached, and all holes for shear-plate hubs shall be 15/16 inch, drilled or reamed.

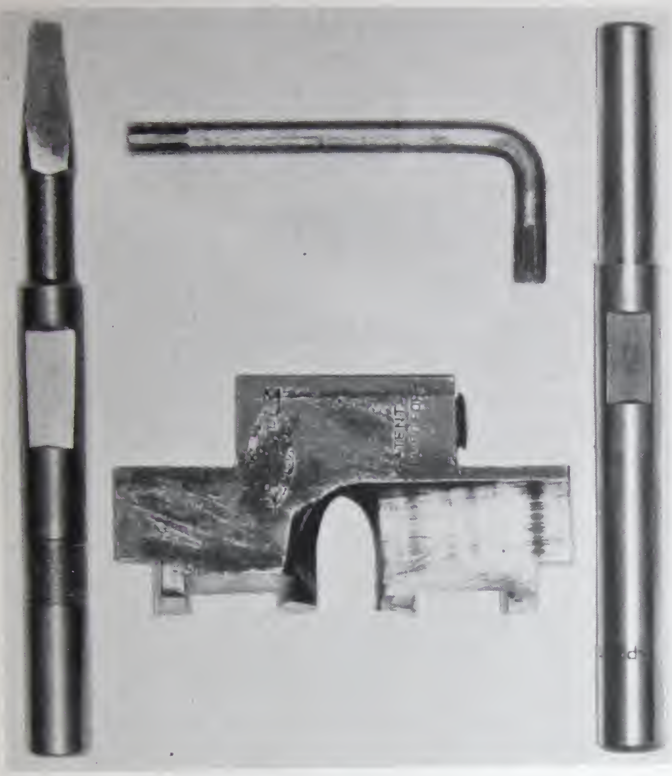
Holes through timbers for bolts used with shear-plates shall be 9/16 inch diameter, carefully centered for connection straps or plates. A circular dap, concentric with the bolt hole, shall be cut in the timber face for each shear-plate by a special dapper * manufactured for this purpose. Daps shall be clean cut and free of torn grain. All chips shall be removed before plates are inserted.

Shear-plates may be installed with bolts and heavy washers, fitted over the hubs, or by blows from a sledge, using a substantial cap or follower to protect the hub. Timbers split or damaged in the process shall be removed from the work and others substituted. Cut washers for ½-inch bolts and not less than 2″ wide shall be placed under the head and nut of each bolt.

SHEAR-PLATE SPECIFICATION DATA

Sizes and Weights			Bolt and Washer Sizes		Minimum Size of Steel Strap in Inches for Number of Shear-Plates per Strap			Diameter of Holes in Steel Strap
Diameter *Inches*	Depth *Inches*	Weight per 100 *Pounds*	Diameter of Bolt *Inches*	Cut Washer *Inches*	1 or 2 Shear-Plates	3 or 4 Shear-Plates	4, 5, 6, or 7 Shear-Plates staggered 2″	*Inches*
3⅛	13/16	59	½	2	⅜ x 2	⅜ x 3	⅜ x 4½	15/16

* All items marked thus are available on a nominal rental or purchase basis from the Timber Engineering Company or its Licensees.



Grooving tool used to cut daps for shear plates. This tool is provided with interchangeable shanks for use in power equipment and for cutting grooves by hand. The latter shank has a pilot threaded to draw the tool into the wood at the proper speed for hand operation.

ASTM STANDARD SPECIFICATIONS A 123-33 FOR GALVANIZING TIMBER CONNECTORS

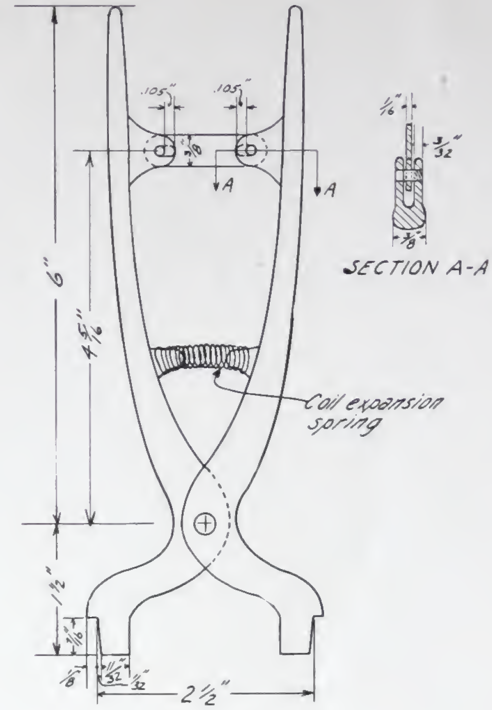
1. Zinc used in the bath shall be at least equal to "Prime Western."

2. The weight of the zinc coating per square foot of actual surface shall average not less than 2.0 oz. and no individual specimen shall show less than 1.8 oz., weight to be determined by stripping an entire piece by ASTM Standard Method A 90-33.

3. The zinc coating shall be adherent, smooth, continuous and thorough, except that uncoated spots on the tongue and groove surfaces in contact will not be cause for rejection. It shall be free from imperfections such as bumps, blisters, gritty areas, uncoated spots, acid and black spots, dross and flux.

4. When visual inspection and testing with ½ lb. hammer is not conclusive, tests shall be made by the Preece method, in which case the minimum thickness of coating shall withstand at least seven 1-minute dips.

5. Test samples may be selected from deliveries at random and will be tested by the purchaser and at purchaser's expense.



PLIER DESIGN FOR
OPENING TECO 2½" SPLIT RINGS
Scale 1" = 1"

Ring spreader. Tools of this type can be secured from the Timber Engineering Company, or details will be forwarded on request for their manufacture by the nearest blacksmith or machine shop. The prongs of the spreader are placed inside the ring and the handles pressed together. This opens the ring to the groove dimensions and makes the placing or removal of rings quick and convenient. Use of ring spreaders is preferable both for greater efficiency of labor and to avoid battering the wood within the grooves.

TYPICAL CONNECTOR CONSTRUCTION

Since connectors became commercially available in the United States early in 1933, several hundred structures have been built employing timber framing with connector joints. These structures range in size from twenty-foot roof trusses to cooling towers a thousand feet in length and include a wide variety of uses. Highway bridges, roof trusses, tank towers, forest lookout towers, trestles, dry docks, cofferdams, oil derricks, pipe racks, gravel bins, and numerous other items have been built with them. Pictures of several typical applications are shown in the following pages.

STRUCTURES EMPLOYING THE CONNECTOR SYSTEM

Roof trusses at plant of Pacific Lumber Company, Scotia, California. These trusses have a span of 50 feet. Connections and splices made with TECO split rings.

Building timber crib work for cofferdams at Bonneville Dam project at Columbia River from Douglas fir. Three thousand 4" TECO split rings were used to secure the necessary strength of connections between timbers in the lower timbers of these cribs.

Installing TECO rings in Douglas fir timbers used for Bonneville cofferdams.

View of the end chord connections of the trusses shown on opposite page. Note that purlins are bolted beneath the chords, so that tops of rafters are flush with tops of truss chords.

Bridge over Dolan Creek on the Coast Highway near Monterey, California. This bridge was completed in 1934. It has a 24-foot roadway and is designed for H-20 loading.

Dolan Creek, Calif. One-hundred-eighty-foot arched timber highway bridge in process of erection. This bridge is of redwood and utilize split rings for joints and splices. In addition to the main arch, there are four thirty-eight-foot lattice truss approach spans supported by timber piers, and several 19-foot trestle bents, also framed with connectors.

Above: Erecting the arch trusses for Dolan Creek bridge. Detailed plans for the structure were prepared and construction supervised by the California State Division of Highways.

Roof trusses for Grace Evangelical Tabernacle, New Orleans, Louisiana. These were of Southern Yellow Pine and joints were made with split rings.

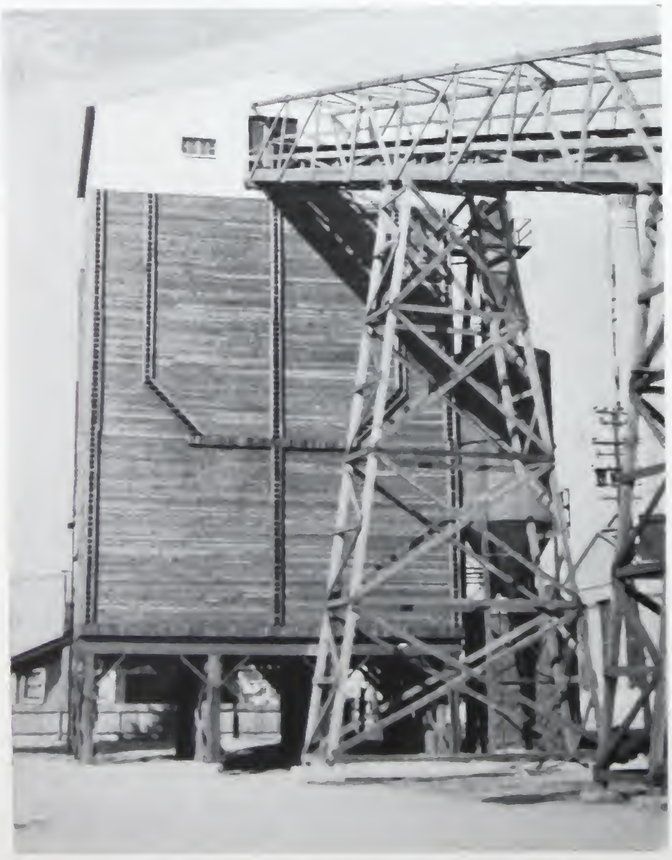
Left: Watertank tower, bracing attached with TECO connectors. The greater strength secured by connectors at such points is a consideration in localities subject to earthquakes or high winds. Douglas fir was used.

Anderson Creek bridge, on the State Highway between Monterey and San Simeon, California, before approach fills were completed. Supporting bents were braced and center trusses connected with TECO toothed rings.

Sixty foot trusses of Southern yellow pine for a Virginia estate riding hall, built with TECO split-ring connectors.

Casing rack for oil field use, as built in the Texas oil fields. Very heavy loads are carried by these racks. Southern yellow pine and TECO split rings.

Rattlesnake Creek bridge, Willetts, California. Three-hinged arch and approach bents framed with TECO connectors.



Trusses and supporting towers for gravel conveyor, connections made with TECO connectors. A Douglas fir structure.

Right: Forest lookout tower nearing completion at Cass Lake, Minnesota. The tower is 100 feet high, exclusive of cab. It is one of several built with TECO split rings by the United States Forest Service. Woods employed were Tidewater Red Cypress, Douglas Fir, Larch, Southern Yellow Pine, and Redwood.

TWO NEW INDISPENSABLE ADDITIONS *to* FUNDAMENTAL KNOWLEDGE ABOUT LUMBER AND ITS UTILIZATION

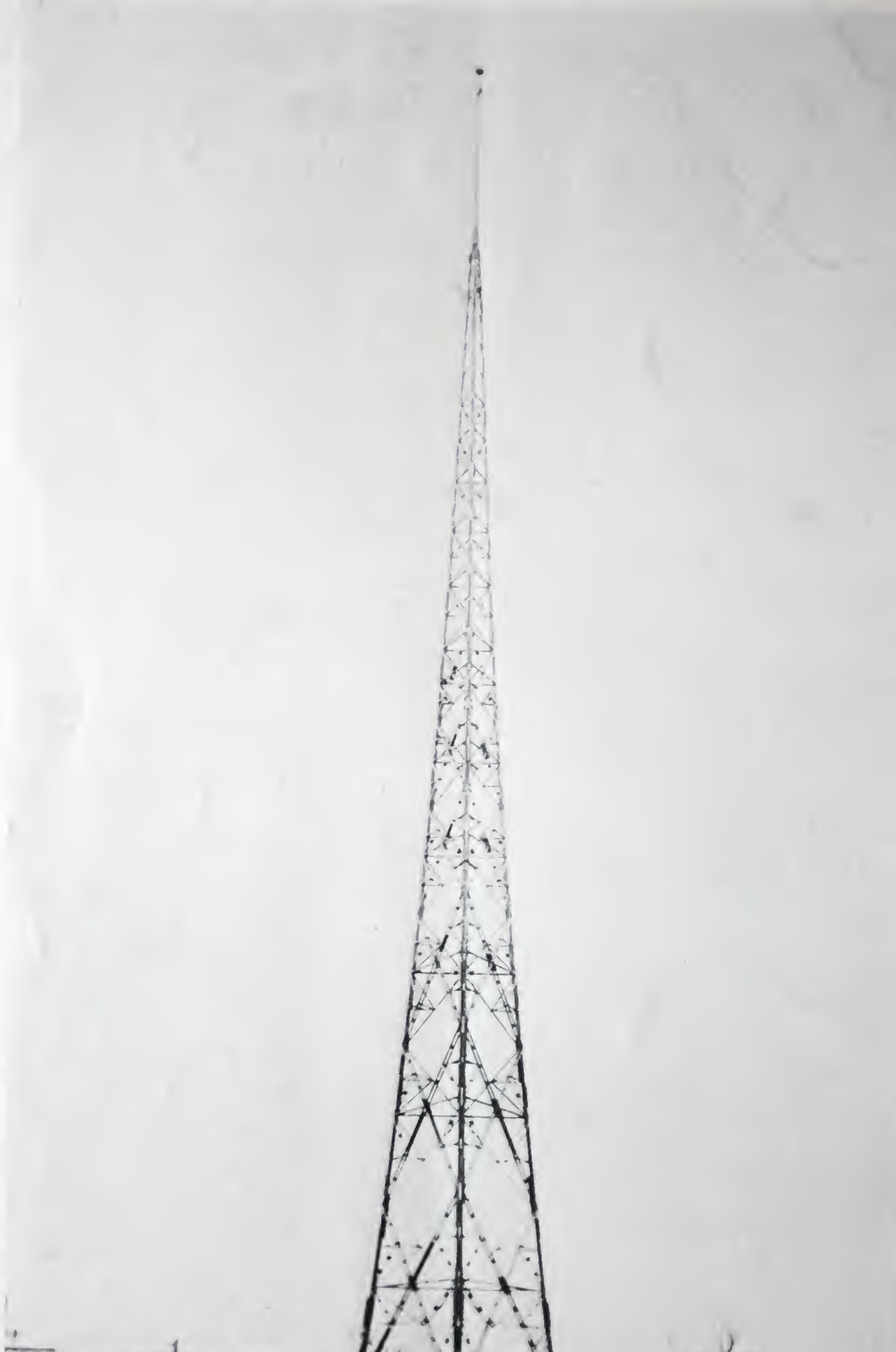
"LUMBER GRADE-USE GUIDE" and "WOOD STRUCTURAL DESIGN DATA"

WOOD STRUCTURAL DESIGN DATA

Is a 300-page book, published by the National Lumber Manufacturers Association. It contains complete tables of safe loads for wood joists, beams and columns covering the full range of commercial sizes, species and grades, and of the spans and heights ordinarily used. The book contains in addition much information on the grading of structural timber, properties of sections, board feet per linear foot and other data useful to designers. Obtainable from the National Lumber Manufacturers Association at a price of $1.00 per copy.

LUMBER GRADE-USE GUIDE

Presents in condensed form, convenient for specifying lumber users, descriptions of the several grades of each commercial lumber species and shows the grades recommended to be used for each construction purpose. Consists of fifteen separate pamphlets aggregating over 200 pages, bound in 3-ring notebook. Price $1.50 per copy.



326 foot, all-wood, radio broadcasting tower of WRVA, the Edgeworth Tobacco Station, at Richmond, Virginia. This is of Longleaf Southern yellow pine; joints were framed with TECO split rings; and the tower is equipped with a new and more effective type of antenna developed by Paul Godley, radio consultant.

Early reports indicate over 200% increase in coverage as compared to the steel tower equipment formerly in use and elimination of numerous "blind spots" in the former area of coverage.